Using Observations from Small Uncrewed Arcraft to Explore the Air-Sea Transition Zone

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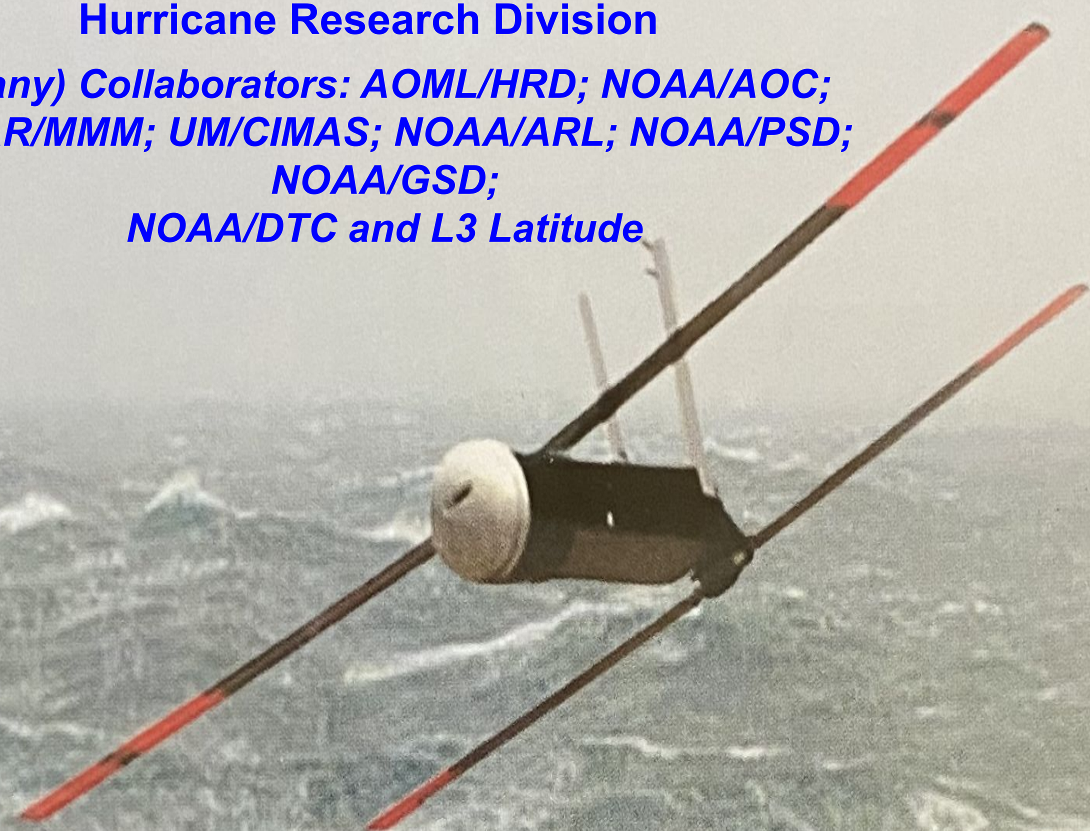

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Tropical Cyclone Operations and Research Forum

March 9th, 2022

small Unmanned Aircraft System (sUAS) Operations in Hurricanes…

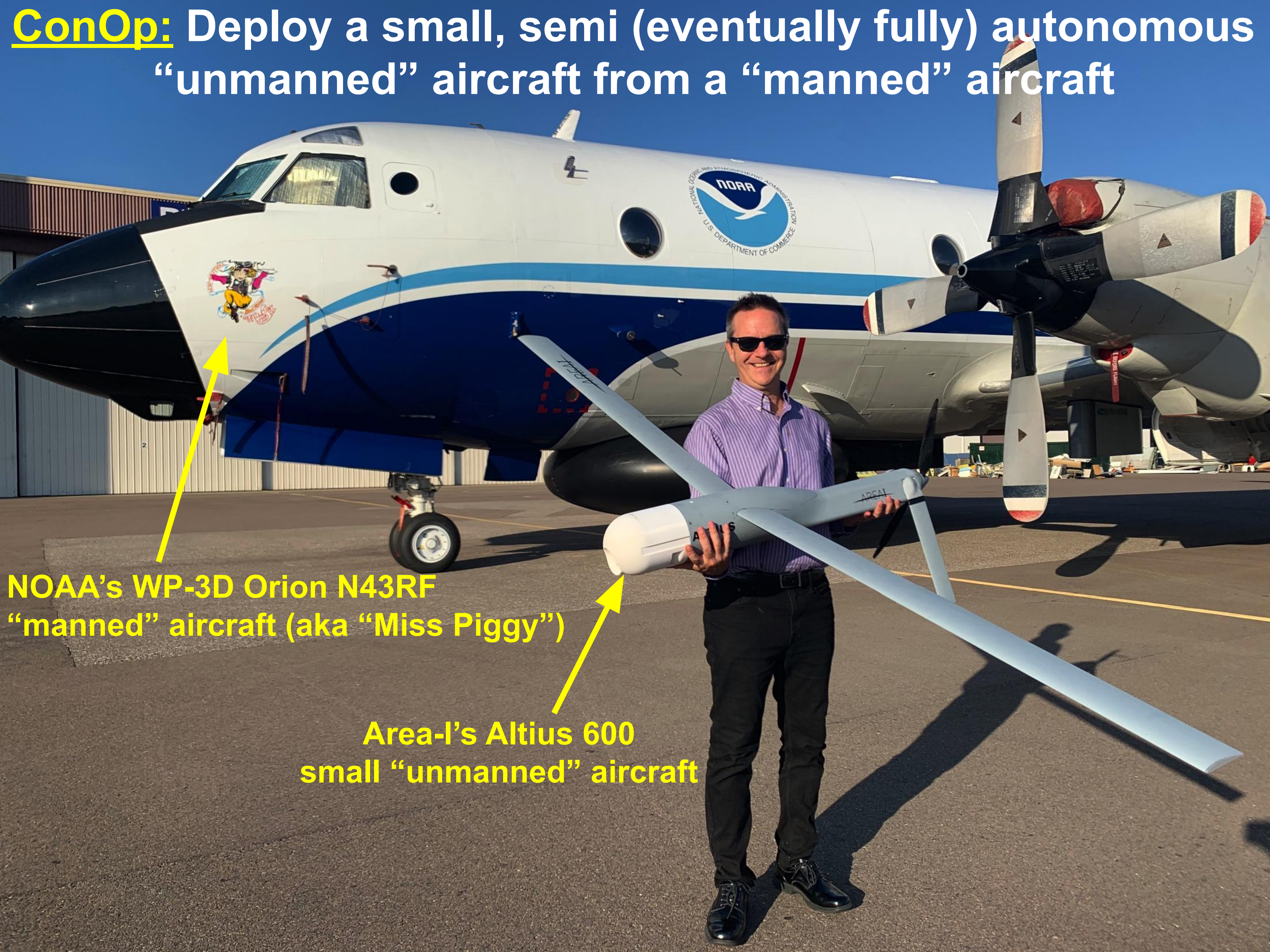
Observational Objective:

Leverage key attributes of NOAA's existing Hurricane Hunter aircraft to develop emerging unmanned technologies designed to enhanced data coverage of the critically important, yet sparsely-sampled tropical cyclone boundary layer environment.

End goal:

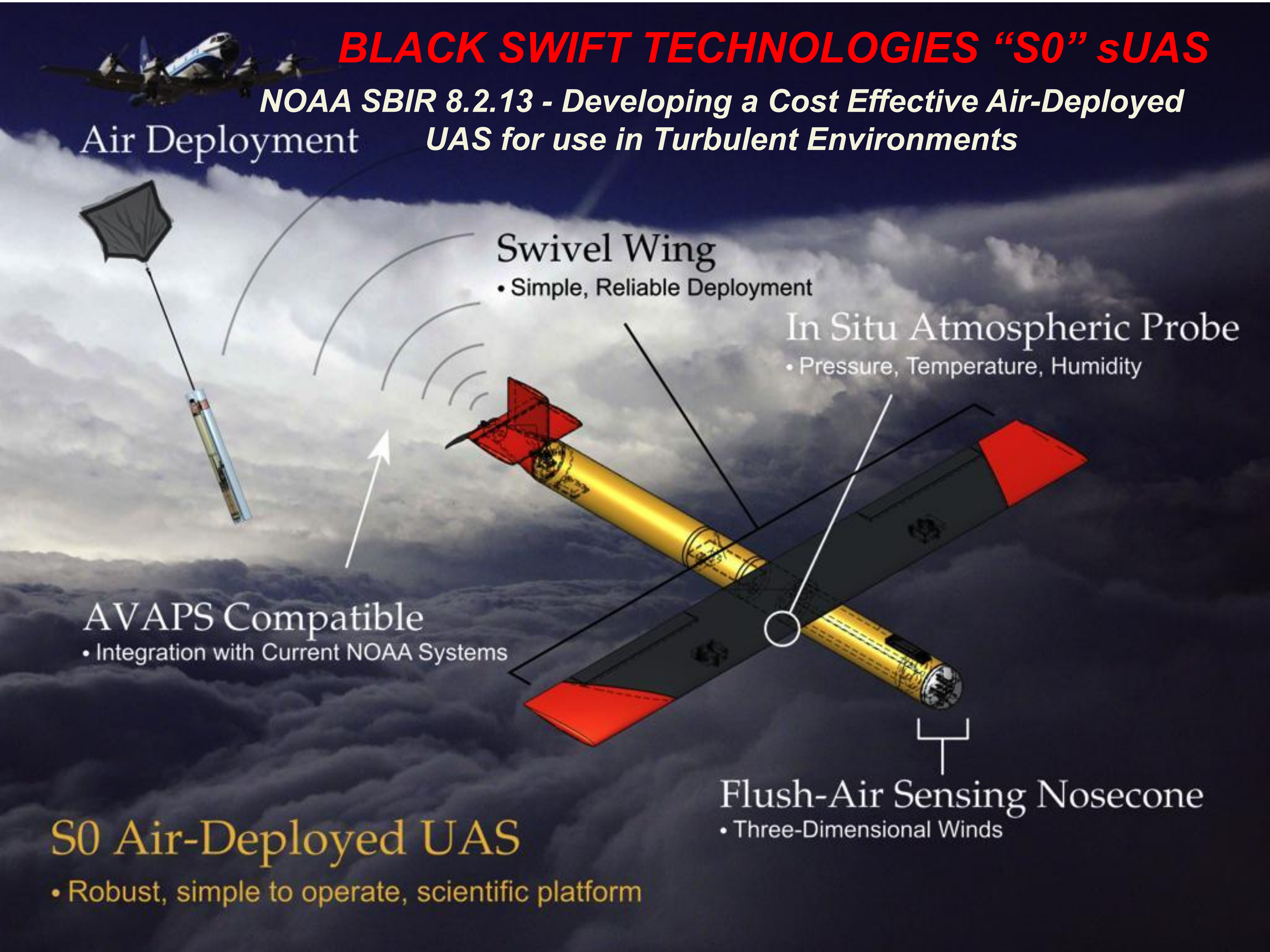
Through enhanced observation, improve basic understanding, operational situational awareness and ultimately, hurricane intensity forecast performance.

ConOp: Deploy a small, semi (eventually fully) autonomous "unmanned" aircraft from a "manned" aircraft



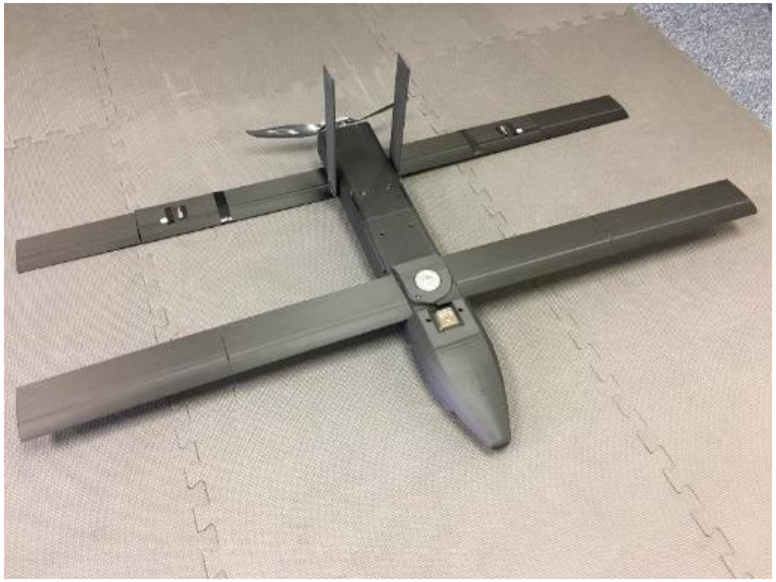
Launch!

Post-Launch:


BLACK SWIFT TECHNOLOGIES "S0" sUAS
NOAA SBIR 8.2.13 - Developing a Cost Effective Air-Deployed UAS for use in Turbulent Environments
Air Deployment
Swivel Wing
• Simple, Reliable Deployment
In Situ Atmospheric Probe
• Pressure, Temperature, Humidity
AVAPS Compatible
• Integration with Current NOAA Systems
Flush-Air Sensing Nosecone
• Three-Dimensional Winds
S0 Air-Deployed UAS
• Robust, simple to operate, scientific platform

BARRON ASSOCIATES – WINGSONDE sUAS

Fully-Assembled Tube-Deployed Model



- Size: Wingspan 119cm (47 in) / Weight 4kg (8.8 lbs)
- Performance: 22m/s cruise speed / 2h flight endurance
- All deployment mechanisms integrated to deploy and lock flight surfaces
- Propulsion system integrated
- Vaisala RSS421 sensor integrated into nosecone
- Initial autopilot integration and electrical wiring

NOAA SBIR 8.2.13 - Developing a Cost Effective Air-Deployed UAS for use in Turbulent Environments

BARRON ASSOCIATES
Proprietary

ALTIUS-600

Overview

- Endurance: 4 hrs
- Cruise speed: 55 KIAS
- Dash speed: 90 KIAS
- Cruise range: 220 Nm
  - Excludes launch descent glide distance
- Tube-stowed dimensions: 6”x40”
- Deployed wing span: 100”
- Deployed length: 40”
- Gross Weight: 23-27 lbs

- Air and ground launchable
- Fully integrated with the Air Force Common Launch Tube (CLT)
- Modular Payload:
  - Weight: 3-6lbs
  - Volume: 6” diameter by 7” length
  - ISR, C-UAS, EW, Kinetic, METOC, etc.
- Successfully air launched from C-130A, AC-130J Ghostrider, UH-60M Blackhawk, Cessna Caravan, Beech A36, and others

Requirements for All Future sUAS TC Operations

- **Cost:** **Improvement over GPS dropsonde (~$300/min; $900/3 min) (PBL)**
- **Command/Control:** **150nmi range between sUAS and P3 (C130)**
- **Payload:** **High QC, reliable (Vaisala RD41; NOAA GPS Drop/Up Sondes)**
- **Survivability_1: Consistency, 210-220kt air-deployed launch (P3/C130)**
- **Survivability_2: Severely turbulent, high wind hurricane conditions**
- **Full Autonomy : No onboard sUAS pilots (Similar to Dropsonde release)**

Where are we right now (March 9th 2022)?

- Cost: ALL 3 have, so far, met cost requirements (~$40- $200/minute)
- C2: On 1/12/21 Area-I's Altius 600: 3h duration, 189 nmi (P3-to-sUAS range)
- Payload: All have made strides (ground testing); Altius CAT success
- Survivability (1): Altius: CAT success; Barron, Blackswift: (Unknown)
- Survivability (2): All 3 (Unknown)
- Automation: All in progress…

What's Next?

Preparation for Three (3) CATs at Lakeland 16-31 May 2022
Assuming CAT testing goes well, production for S0, wingsonde □ July 31
In-Storm Testing for all sUAS platforms *August 15* □

2022 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

RESEARCH IN COORDINATION WITH OPERATIONS
SMALL UNMANNED AIRCRAFT VEHICLE EXPERIMENT
(RICO SUAVE)

Science Team: Joseph Cione, Jun Zhang, George Bryan (NCAR), Ron Dobosy (NOAA/ARL-ret), Altug Aksoy, Frank Marks, Kelly Ryan, Brittany Dahl, Josh Wadler, Josh Alland (NCAR), Rosimar Rios-Berrios (NCAR), Gijs deBoer (NOAA/PSL), Evan Kalina (NOAA/DTC), Don Lenschow (NCAR), Xiaomin Chen, Chris Rozoff (NCAR), Eric Hendricks (NCAR), Falko Judt (NCAR), Jonathan Vigh (NCAR)

Plain Language Description: Use small drones to sample the lowest and most dangerous regions of the tropical cyclone. Observations from these unique platforms have the potential to improve basic understanding and enhance situational awareness. Analyses of data collected from these small drones also have the potential to improve the physics of numerical models that predict changes in storm intensity.

2020 NOAA/AOML/HRD Hurricane Field Program – IFEX
MATURE STAGE EXPERIMENT
RICO SUAVE

Goals:

1. Collect PTH, SST and wind observations within the high wind eyewall and boundary layer inflow regions of mature hurricanes.

2. Provide real-time wind data to improve operational situation awareness (RMW/VMax)

3. Improve basic understanding of a sparsely-sampled, yet critically important region of the storm where turbulent exchanges of heat, moisture, and momentum with the ocean and eye-eyewall interfaces regularly occur

4. Use these data to evaluate operational model performance as it relates to boundary layer thermodynamic and kinematic structure and SST ocean response

Hypotheses:

1. 360-degree depictions of hurricane boundary layer RMW and Vmax at multiple altitudes are possible by conducting repeated UAS eyewall orbit missions

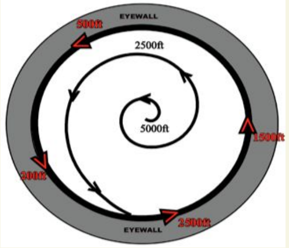
2. Accurate depictions of the TC thermodynamic and kinematic inflow layer (100-1500m) and TC-induced cooling are possible using dropsonde, AXBT and sUAS strategically deployed observations

3. Eye loitering, TC center fixes, eye-eyewall targeting, and documentation of TC-induced cooling are possible using sUAS

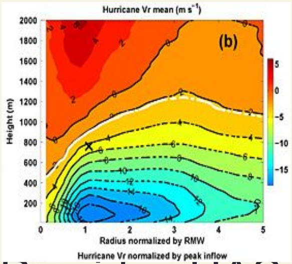
2020 NOAA/AOML/HRD Hurricane Field Program - IFEX
MATURE STAGE EXPERIMENT
RICO SUAVE

Objectives:

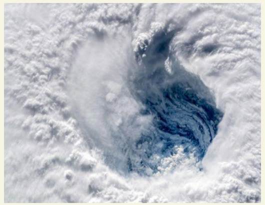
Eyewall Module: Provide sUAS HDOBS at multiple altitudes and azimuths to NHC in near real time. Post storm, comparing sUAS atmospheric and SST high wind observations with operational analysis and forecast fields from coupled HWRF and HAFS.

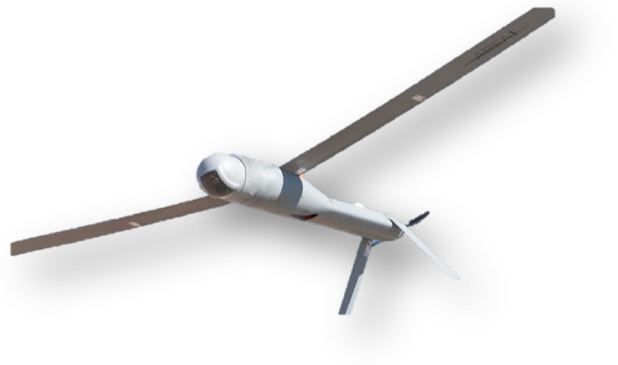


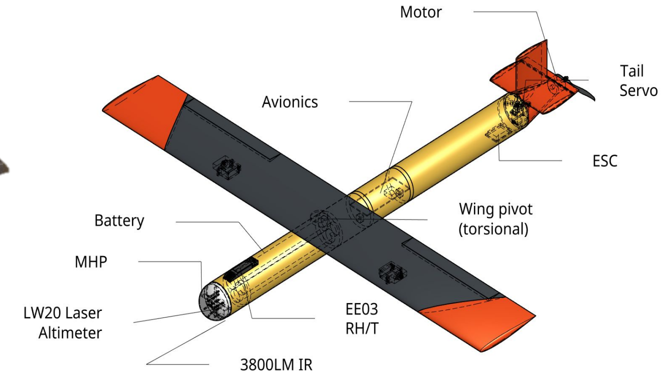
Inflow Module: Provide sUAS HDOBS in near-real-time to NHC. Post storm, compare sUAS TC boundary layer thermodynamic, kinematic and SST radial structure with model output to improve TC boundary layer parameterizations and ocean response in HWRF and HAFS.



Center Fix/Eye-Eyewall Module: Provide sUAS HDOBS and center fix estimates in near-real-time to NHC. Post storm, compare sUAS TC boundary layer thermodynamic, kinematic and SST structure within the eye and eye/eyewall interface with mode output to improve TC boundary layer parameterizations and ocean response in HWRF and HAFS.







Summary

- Observations from small Unmanned Aircraft Systems (sUAS) have the potential to enhance the basic understanding of dangerous and difficult to observe regions of the Tropical Cyclone, including the critical air-sea interface.
- These unique data have the potential to improve situational awareness and future forecasts of Tropical Cyclone intensity change using NOAA's operational coupled-ocean atmosphere modeling system.
- As technology advances, small drones (such as the three new platforms highlighted today) will be able to fly longer, lower and for less money.
- Working with public and private partners, NOAA will continue to explore this promising technology over the coming years in order to help the Agency better meet its ultimate goal of protecting property and saving lives.

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Telemetry “Video” in Hurricane Maria

Questions?